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National Cultivar Improvement

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For cultivar improvement the best sources of each required agronomic character are sought from wherever available for recombination and transfer into major commercial bean types for national production programs (Table 1) The number of desirable characters and their relative order of priority may vary according to production region

Recombination of two or more traits could be done simultaneously--e g rust and common bacterial blight or anthracnose and angular leaf spot--or separately--e g drought and anthracnose or anthracnose and bean golden mosaic virus For the latter segregating populations and selected progenies are screened for individual traits in alternate generations followed by simultaneous evaluation in separate nurseries of advanced lines This usually slows the genetic progress and requires a relatively longer time Also as the number of characters to be recombined increases realized genetic gain at the end of each selection cycle decreases

The following data were gathered in 1981 for bean types and bean-production regions

Bush Beans

Andean Region

Genetic progress in improvement of commercial varieties for Andean regions has been very slow This is primarily due to susceptibility to BCMV of all parental materials from this region and difficulty in rapid recovery of the desired grain colors and sizes (medium and large red red-mottled etc) each of which is controlled by several genes when crossed to BCMV-resistant small-seeded parents from other areas Nonetheless from crosses made during 1979-80 nearly 1500 families of commercial grain types were evaluated at CIAT-Palmira in the 1981B season In the first evaluation of these families in the glasshouse it was evident that the homozygous resistance conferred by the dominant I gene is not available yet in medium and large red-mottled grain types However most of these are uniform for growth habit and maturity Further evaluation of these lines and purification of other promising families should be completed in the coming seasons

Argentina

Breeding for Argentina was initiated on a small scale in June 1979 In 1981 from the first group of crosses 25 experimental lines carrying resistance to BCMV were developed Of these two lines A 494 and A 497 are similar to Alubia the local commercial variety in grain

Table 1 Principal production regions of Latin America their bean types responsibilities of breeders and corresponding international yield trials

Basic group	Grain characteristics: Color	Grain characteristics: Size	Representative varieties within each group	Production regions	Breeder[a]	International yield trial
1	Black	Small	Jamapa Porrillos ICA Pijao Turrialbas Tacarigua Rio Tibagi Iguacu Moruna San Martín	Coast of Mexico Central America Caribbean Venezuela Southern Brazil	I	IBYAN 10000
2	Red[b]	Small	Zamorano Mexico 80 Rojo de Seda Honduras 46	Central America	I	IBYAN 20000
3		Medium & Large	Calima Andino Uribe Liborino Cargamanto Mocho Sangretoro Pompadour	Andean Region Dominican Republic Haiti Africa	III	IBYAN 25000
4	White	Small & medium	Panamito Arroz Blanquillo Caballero Cristal Fenix	Peru Ecuador Colombia Chile	I	IBYAN 30000
5		Large	Alubia	Argentina	II	IBYAN 35000
6	Cream[b] Brown[b]	Small	Carioca Rosinha Chumbinho Roxao Mulatinho	Brazil	II	IBYAN 50000
7	Pink[b] Cream[b] Black Brown	Medium	Flor de Mayo Pinto Ojo de Cabra Bayos Puebla 152 Garbancillos Zarcos	Mexico temperate highlands	II	IBYAN 40000
8	Yellow[a]	Large	Tortolas Bayos Canarios Azufrados	Chile Coast of Peru Coast of Ecuador Mexico	I	IBYAN 60000
9	Red[b]	Medium & large	Mortiño Bolon Rojo Cargamanto	Andean sierra	III	VIRAF 70000
10	Cream[b] Yellow White	Medium & large	Bolon Amarillo Canario Caballero	Andean sierra	III	VIRAF 80000

a See Table 8 Chapter 1 for definition of breeder responsibilities
b Implies solid as well as mottled striped and/or speckled types

characteristics Resistance to common bacterial blight angular leaf spot rust anthracnose and drought is being incorporated in the second round of crossing undertaken this year

Brazil

From the start in 1976 improvement of germplasm of dry beans for Brazil has received maximum attention at CIAT Experimental lines of mulatinho and black grain types with resistance to BCMV in all and rust and angular leaf spot in some have become available since 1978 A few pardo carioca and roxo grain types were also available in 1979 and 1980 and so were the resistances for at least one additional production-limiting factor that is resistances to anthracnose common bacterial blight low soil phosphorus BGMV Empoasca or drought were combined in some lines In 1981 nearly 200 new lines were bred which brought the total to over 500 developed lines for Brazil so far This year the number of lines for each commercial grain color (Table 11 Chapter 1) was roughly proportional to the area planted in the country A major improvement over the past year was that in addition to BCMV resistance an intermediate reaction for anthracnose became a common characteristic of the majority of bred lines A few lines in each grain color also carry resistance in various combinations for two or three more production-limiting factors Preto (black) mulatinho and carioca grain types with resistance to either anthracnose angular leaf spot rust or common bacterial blight or a combination of two of them were also developed this year

Breeding of growth habit Types I and II with improved erect and upright plant architecture and range in maturity for mulatinho and carioca grain types which are traditionally Type III varieties would benefit mechanization of bean cultivation in Brazil

A total of 118 crosses was made this year for further improvement over these newly bred lines Increasing emphasis is now being given for combining resistance for three to five production-limiting factors in required commercial grain types and increasing their current yielding potential However the incorporation of tolerance to BGMV and drought neither present in Colombia is still lacking Closer collaboration and increased participation of the national institutions is essential if a satisfactory genetic solution is to be found for these two overriding production problems

Nearly all bred lines and sources of desirable traits were made available to the national bean improvement center CNPAF at Goiania Brazil Also partial or complete sets based on grain type preferences were sent to several state organizations upon specific request

Mexico--Temperate Highlands

Importance of the medium-sized bayo-colored bean varieties was only realized during our Mexican trip in September 1980 Until that

time we had not undertaken any breeding work for this most extensively grown bean type in the highland states of Mexico Neither had we known the magnitude of the bean-production problems of that area The number of lines derived from the first group of crosses made in 1978 for the Pinto Flor de Mayo and Ojo de Cabra grain types increased over the last year Most of these carry resistance to anthracnose and a few to common bacterial blight As with the Andean-region materials it has been difficult to recover Flor de Mayo grain types from most crosses However one line A 409 similar to Flor de Mayo in grain characteristics was selected with resistance to BCMV Increasing emphasis is being given to combine resistance to drought Epilachna rust and Apion

Small Reds--Central America

Improvement of small red grain types has progressed rapidly BCMV resistance has been incorporated into a diverse number of lines with commercial grain type This in turn has facilitated the improvement of agronomic characters and the incorporation of resistance to other diseases Rust and anthracnose resistance have now been incorporated into several commercially acceptable lines

This year we made several important advances in the improvement of small red grain types From crosses made in 1980 we have selected lines of upright architecture and heavy pod load characteristic of higher yielding black grain varieties In addition we are now evaluating several lines of commercial grain type with high levels of resistance to common bacterial blight The program continues to emphasize the development of multiple disease-resistant varieties with upright architecture and heavy pod load Though early maturity is emphasized we continue to select lines with a range of maturity to suit specific growing conditions Several lines selected in Central America in conjunction with national programs appear to have high yield potential indicating the value of local selection We are progressively sending more early-generation materials to Central America for selection under local environmental and disease conditions

Blacks - Mexico Central America Brazil

Varietal improvement of black grain varieties has been directed toward the incorporation of disease resistance to stabilize their high yield potential Resistance to rust BCMV BGMV and Empoasca has earlier been incorporated into black-grained varieties by national programs and CIAT CIAT is now emphasizing the selection of multiple disease-resistant lines combining resistance to two or three diseases into single varieties At the same time we are continuing to increase levels of resistance to these and other diseases such as common bacterial blight This year we have selected at least one family of the black opaque grain type with a high level of resistance to common bacterial blight We consider this an important advance because earlier we were able to recover common blight resistance only in

commercially unacceptable brilliant-black grain types The primary challenge today is to develop multiple disease-resistant black opaque grained varieties while maintaining or increasing the yield potential

Red Mottles--Caribbean

Our primary goal for red-mottled grain types for the Caribbean region has been to incorporate the I gene for BCMV resistance Transfer of the I gene has been difficult due to an apparent linkage of genes controlling the red-mottled color with the i gene for susceptibility Several light purple grain colored bean lines have been developed with I gene resistance these have been advanced into VEF and EP evaluations In 1980 we recovered true red-mottled grain types with the I gene resistance These lines however had small grain size and were opaque This year we have improved these lines increasing the size and brilliance We are in the process of incorporating common bacterial blight and Empoasca resistance two important yield-reducing factors which this grain type has traditionally lacked In the development of varieties for the Caribbean we are selecting large-seeded materials with traditional determinant Type I growth habit But in addition we are selecting indeterminant upright Type II materials with medium-sized seed as a higher yielding alternative

Canarios Bayos--Peru and Mexico

With large advances with small reds black opaques and Brazilian grain types increased priority has been placed on the improvement of canarios and bayos As with red-mottled grain types I-gene BCMV resistance has been difficult to incorporate into bayo and especially canario grain types CIAT will continue to emphasize incorporation of the I gene into commercially acceptable grain types In a parallel program we are in the process of incorporating multiple recessive genes for BCMV into these grain types Several breeding lines of commercially acceptable color with I-gene resistance have been developed grain size now needs to be increased in order to develop commercially acceptable varieties

Peruvian-adapted materials of this class have proven to be poorly adapted to CIAT growing conditions Because of this difficulty CIAT is increasingly sending early-generation materials homogeneous for BCMV resistance to Peru for on-site selection Similarly early-generation materials will be sent to Mexico for selection under local conditions at national program experimental stations

Small Medium Whites--Peru Ecuador Chile

Primary breeding objectives for small and medium white beans has been the development of clean white grain colored varieties with rust and Empoasca resistance Less emphasis has been placed on drought

tolerance another important factor for this grain group due to inherent difficulties in screening for this character Bean yellow mosaic virus resistance and the multiple recessive gene resistance to bean common mosaic virus are important factors for medium whites and other grain types of Chile Due to the limited capacity for screening these materials on location in Chile a low level of activity has continued in the incorporation of these factors into adapted varieties

Of 24 white grain lines entered in the 1980 VEF seven were advanced to the 1981 EP of these seven BAT 1280 and 1282 two small-seeded lines appear very promising BAT 1282 is a high-yielding line with good levels of resistance to rust and Empoasca Two advanced lines BAT 338 and BAT 482 also with resistance to rust and Empoasca continue to do well in IBYAN trials This year the number of promising small and medium white breeding lines entering the VEF trials has more than doubled now totalling 53 entries

Climbing Beans

Sources of outstanding resistance to diseases pests and other factors from the specific character-improvement programs are used as parental sources for incorporating into agronomically suitable materials with commercial grain types The parental sources may have any growth habit although where suitable climbing bean material is not available growth habit Types II and III have been found to give better climbing progenies with Central American grain types (reds and blacks) and habit I generally combines well with Andean types (large grains) (Growth habit I generally differs from habit IV only by a single recessive gene for the determinate dwarf character) Resistance sources are chosen according to the particular needs of the regions where each grain type is grown (Annual Report CIAT 1980) Some degree of resistance to individual factors often has to be sacrificed in this process of recombination Parental stocks of each grain type are continually renovated As information accumulates on the value of progeny some parents are more widely used others discarded New well-adapted germplasm collections are included as parents as well as our own promising lines resulting in a continual turnover

Small Red Grains for Central America

The commercial varieties currently included for improvement are Rojo 70 (growth habit Type IVa) Rojo de Seda Zamorano and Compuesto Alajuela (all Type IIIb) and several varieties selected from the germplasm collection Relay planting with maize in the second semester of the year is perhaps the most important production system for these varieties although some are planted in the first semester either in monoculture or in association with maize Principal limiting factors are BCMV rust bacterial blight and Empoasca but anthracnose and angular leaf spot are also important in some areas Progenies from crosses are tested alternately in association and relay with maize in

both Palmira and Popayan They are evaluated for disease and pest reaction in the field using susceptible varieties as spreaders and in the glasshouse for BCMV and anthracnose The most promising lines so far identified for international yield testing are V 7844 V 7910 V 7920 and V 79119 (Table 2) While these are improved for resistance to BCMV rust and Empoasca they still lack resistance to bacterial blight

A total of 69 lines were advanced to the VEF in 1981 10 of which are growth habit Type IIIb and the remainder are Type IVa

Black Grains

Climbing beans (Types IVa and IVb) with black grains are important for relay and association with maize in the highlands of Guatemala and parts of Mexico Principal production constraints are considered to be anthracnose ascochyta rust angular leaf spot and Apion Screening of potential parents and progeny has been carried out in collaboration with ICTA Guatemala In Colombia work is concentrated in CIAT-Popayan Varieties selected in Guatemala which have been used in crossing include Quinac Ixim Guate 1213-CM Guate 1201-CM Guate 933-CM Guate 1174-CM (Type IVb late) Guate 998-CM and Chimal 80-4 (Types III or IVa early) As sources of resistance the following lines have been used G 5767 (Negro 150 resistant to Apion) G 5954 (resistant to BCMV and anthracnose) G 6074 (resistant to anthracnose and halo blight) and G 6342 (resistant to anthracnose and rust) The search for resistance to ascochyta is taking two courses First to build up low levels of resistance crosses are made between the most promising lines so far identified these include G 5927 (Guate 41) G 6342 (SX-62-39) G 6040 (Guate 488) G 4201 G 5926 (Guate 46) G 6079 (Guate 593) G 5960 (Guate 196 B) and V 8017 Second interspecific hybrids have been made with selected varieties of Phaseolus polyanthus and P coccineus (Guate 1076-CM and lines from Puerto Rico) These have reached the stage of F_3 progenies

A total of 39 lines with black grains were entered into the VEF in 1981 they were selected mainly for resistance to anthracnose and BCMV Their growth habit is Type IVa earlier than traditional varieties and therefore suitable for testing with earlier improved maize genotypes

Andean Highlands Project Convenio ICA-CIAT

In the highlands of Bolivia Colombia Ecuador and Peru preferred grain types are large and of various colors except black Most traditional varieties are vigorous climbers (Type IVb) which are late (6-10 months depending on altitude and variety) and are planted at low densities (1-3 plants/m^2) in relay or in association with maize The principal limiting factors apart from maize competition are anthracnose ascochyta rust and root rots of secondary importance are angular leaf spot powdery mildew and halo blight Disease pressure is heavy made worse by a lack of rotation Improvements are being sought

Table 2 *The most promising climbing bean lines for Central America with small red grains compared with two commercial varieties*

CIAT No	Resistance to						Growth habit	Color	Parents
	BCMV[a]	Rust[b]	CBB[b]	Empoasca[b]	Anthracnose[b]	Angular leaf spot[b]			
V 7844	R	1	4	2 7	5	4	IIIb	Red	G 4122 x G 3353 x G 2115 x G 5476
V 7910	R	2	4	2 9	2	3	IIIb	Pink	G 5701 x G 3353
V 7920	R	2	4	2 9	1	1	IVa	Opaque red	G 1813 x G 1248 x F 3709 x G 4489
V 79119	R	2	4	3 8	1	1	IIIb	Red	G 3645 x G 2115
G 5701 (Rojo 70)[c]	S	5	4	4 5	2	4	IVa	Red	
G 7126 (Rojo de Seda)[c]	S	4	4	4 5	5	4	IIIb	Red	

a R resistant S susceptible
b Scale 1 immune 5 very susceptible
c Control commercial varieties

in disease resistance combined with an earlier IVa plant type with a higher harvest index Improved materials cause less lodging in the maize and therefore can be planted at higher densities with earlier varieties of maize Results demonstrating the effect of plant type on density response are shown both for association and relay in Table 3 The earlier less vigorous plant types are potentially higher yielding when combined with suitable disease resistance

A total of 76 new germplasm accessions were identified as promising for the Andean region in particular G 12730 (Frijol from Mexico) and G 12417 (E 884-1 from Ecuador) for relay for association the following were promising G 8160 (Antioquia 123) G 8216 (Cajamarca 126) G 8172 (CAL -5) G 1226 (Ecuador 176-2) G 12488 (E 1056 from Ecuador) G 12289 (Ecuador 472) and G 8169 (BOY -116A) Lines with growth habit IVa continued to yield better in relay than Types IVb or IIIb (Table 4) while Type IVb was superior for yield in association with maize (Table 5) The IVa growth habit is slightly earlier than the IVb and tends to have smaller grains Selection in the early generations of hybrid populations is being directed toward Type IVa for association with earlier maize cultivars For relay selection is directed toward Types IVa and IIIb

In F_2 single-plant selection nurseries a total of 1420 plants (3 5%) was selected from a total population of 40 902 The best parents for resistance to anthracnose and adaptation have been G 12727 (AB 136) G 5694 (Cornell 49-242) G 2025 G 4356 and G 5653 (Ecuador 299) In F_3 progeny tests for anthracnose (inoculated in the glasshouse) 75% of the lines selected in ICA-La Selva and 47% of those from ICA-Obonuco were segregating for resistance or were resistant to anthracnose A total of 79 lines with large red grains and 25 with large cream or yellow grains from the Andean highlands were advanced to the VEF

Table 3 Yield response to planting density and different cropping systems of bean varieties of two contrasting plant types in ICA-La Selva with constant maize density

Characteristic	Yield (kg/ha)			
	Associated cropping		Relay cropping	
Bean density (plants/ha)	47 000	120 000	47 000	120 000
Bean yield (kg/ha)				
ICA-Viboral[a]	644	536	1 345	1 079
G 7908[b]	763	1 251	1 534	2 014
LSD	362		444	

a ICA Viboral = Type IVb improved selection from Cargamanto (released in 1979)
b G 7908 = Type IIIb red grain collection Guatemala 432

Table 4 Characteristics of selected bean lines in relay with maize according to plant type in ICA-La Selva

Characteristic	Growth habit IIIb	IVa	IVb
Lines (no)	5	43	39
Days to physiological maturity (no)	131	134	147
100-seed weight (g)	28	29	36
Yield (kg/ha)	792	956	596

Table 5 Characteristics of selected bean lines in association with maize according to plant type in ICA-Obonuco

Characteristic	Growth habit IIIb	IVa	IVb
Lines (no)	9	46	59
Days to physiological maturity (no)	185	194	201
100-seed weight (g)	62	60	62
Yield (kg/ha)	363	834	1165

Two new lines were tested in Antioquia in the series of on-farm trials These were V 3230 and V 3227 both the result of crosses with Cargamanto which was selected for resistance to anthracnose The most promising selection from the year before E 1056 was included again as it had demonstrated that farmers could obtain higher net income with reduced inputs due to its resistance to anthracnose Seven new lines were selected for on-farm trials in Narino in association with maize Four of these were from the ICA program (L 33003-M(4) L 32980-M(4) L 32980-M(8) and L 32983) and three were selected in the collaborative project (E 605 E 525 and E 521) The new lines are between 1 and 2 months earlier than the traditional variety Mortiño